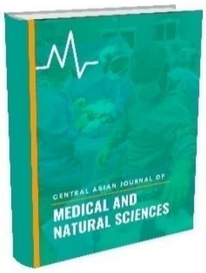
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Possibilities of Modern Radiation Methods of Breast Pathology

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Abstract: Every year more than 1 million new cases of breast cancer are registered in the world. To choose the right tactics for treating patients, it depends on the timely diagnosis and the correct assessment of the prevalence of the tumor process.

The algorithm for examining patients includes a clinical examination, X-ray mammography and ultrasound examination of the mammary glands. However, this is not enough for a full interpretation of the patient's condition in the case of non-palpable formations of the mammary glands, ambiguity in the interpretation of visualization during structural rearrangements, increased density of breast tissue, etc.

In this regard, the introduction of new technologies and their evaluation from a practical standpoint is a pathological and developing direction in the early diagnosis of breast pathology.

One of the methods that can increase the information content of ultrasound examination of the mammary glands is elastography. It allows differential diagnosis of benign and malignant changes not only in the breast tissue, but also in the areas of regional lymphatic drainage.

A promising area of modern diagnostic mammology is mammographic digital tomosynthesis. However, despite the first and very optimistic data, this technique is still far from the standard.

Comprehensive diagnosis of breast pathology, in addition to clinical data and imaging results, is based on information obtained from biopsies. At the present stage, the core biopsy is considered to be the optimal method of verification, in which the resulting material is subjected to immunohistochemical examination.

Keywords: mammography, ultrasound, breast, elastography, pathology, diagnostics, tom synthesis, core biopsy.

Thus, the range of diagnostic possibilities is constantly expanding. Highly informative techniques, which are included in everyday practice, already now allow clinicians to achieve optimal results in curing even more patients.

Important features of malignant neoplasms of the mammary gland are a high growth rate, territorial and geographical uneven distribution of morbidity levels.

In the structure of oncological morbidity and mortality of the female population in the world, breast cancer (BC) ranks first (32% of all cancer cases in developed countries).

Every year more than 1 million new cases of breast cancer are registered in the world, more than 500 thousand women die. According to rough estimates, annually in Europe the incidence of breast cancer is 115 per 100 thousand women, the mortality rate is 41.3 per 100 thousand women. These figures vary greatly in different geographic areas.

It's not a secret for anyone that the choice of adequate tactics for treating patients depends on the timely diagnosis and the correct assessment of the prevalence of the tumor process.

In this regard, the widespread introduction of various imaging methods, which could improve and replenish the amount of information obtained with standard methods of radiodiagnosis, is of particular relevance.

The initial diagnostic algorithm for examining patients has long been established. It includes a clinical examination, x-ray mammography and ultrasound examination (ultrasound) of the mammary glands. However, this is not always enough for a full interpretation of the patient's condition. A similar dissonance arises in the case of non-palpable formations of the mammary glands, ambiguity in the interpretation of visualization during structural rearrangements, with increased density of the gland tissue, etc.

Clinical examination has low sensitivity indicators (no more than 45-50%) and does not always exclude the presence of a malignant tumor (especially with non-palpable formations).

Radiologically, in this case, the following symptoms are noted: mass formation, asymmetry of tissue density or micro calcifications. At the same time, discrepancies in the meager visual and morphological manifestations of the process are observed.

A similar situation is associated with the use of ultrasound. With this imaging option, the definition of pathological changes is associated with the presence of a volumetric formation, the density of which exceeds the background density of the surrounding breast tissues, low echogenicity with signs of an infiltrative type of growth. In a certain sense, dopplerography provides clarifying information with traditional ultrasound. In early malignant lesions, these are: high blood flow velocity and atypical Doppler curves due to the formation of arteriovenous shunts.

Of the existing standard methods for imaging the mammary glands, magnetic resonance imaging (MRI) can be evaluated as a method of clarifying diagnosis. Breast cancer, not detected by X-ray and ultrasound examination, can be diagnosed using MRI. MRI is a highly effective method for diagnosing the mammary glands - its specificity ranges from 37-97%.

In this regard, the introduction of new technologies and their evaluation from a practical point of view is a logical and developing direction for the early diagnosis of breast pathology.

One of the methods that can increase the information content of ultrasound of the mammary glands is a new technology - elastography. This method is based on the assessment of tissue stiffness. There are compression elastography (static and real-time) and shear wave elastography.

The well-known fact that malignant degeneration is characterized by an increase in tissue stiffness and resistance has allowed some authors to call elastography echopalpation. Tissue evaluation in elastography is possible using qualitative parameters - based on color cartograms and quantitatively - based on the assessment of stiffness parameters (Young's modulus) in kilopascals (kPa).

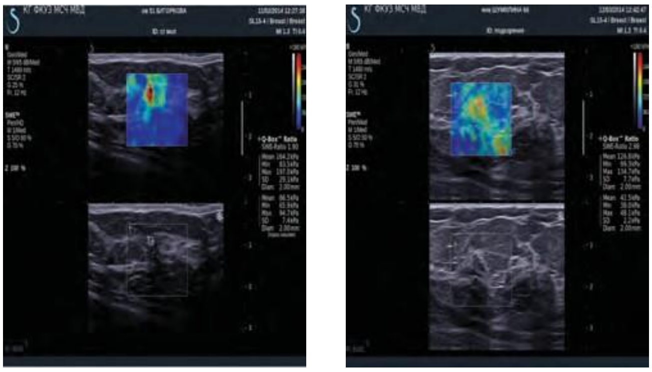


Figure. 1. Image of breast cancer in the mode of ultrasonic shear wave elastography.

Compression elastography with the ability to assess the qualitative characteristics of tissue stiffness has received the widest practical implementation. In the studies conducted, the compression elastography method demonstrated the following diagnostic characteristics: accuracy (mean value 87.9–88.3%), specificity (mean value 80.7%), sensitivity (mean value 75%) in visual verification of breast cancer. Shear wave elastography, in comparison with compression elastography, due to the possibility of carrying out not only qualitative, but also quantitative assessment of tissue changes, is characterized by higher accuracy rates in the differential diagnosis of a benign and malignant process (Fig. 1).

The data of foreign and domestic authors testify to the high information content of shear wave elastography. Quantitative signs of stiffness: Emean > 55 kPa - breast cancer with a sensitivity of 97.7%, a specificity of 85.9%; Emax > 85.7 kPa - breast cancer with a sensitivity of 97.7%, a specificity of 87.5%; SWE-ratio > 3.5 – breast cancer with sensitivity 100%, specificity 82.8%.

Elastography allows differential diagnosis of benign and malignant changes not only in breast tissue, but also in areas of regional lymphatic drainage (assessment of the degree of locoregional progression in cancer). The use of this technique in non-palpable formations makes it possible to detect changes that are not detected by standard ultrasound in B-mode. Ultrasound breast elastography is considered as a method that can improve the differential diagnosis of small cysts with dense contents and small fibroadenomas.

It has been shown that the use of elastography in certain cases allows more correct interpretation of radiosonographic changes. This eventually changes the education category (from BIRADS 4 to BIRADS 3). The latter affects the management of the patient, allowing to reduce the number of unnecessary biopsies.

Assessing the role of various elastography options in modern ultrasound diagnostics, C. Weismann et al. emphasize that elastography is not an independent diagnostic technique, but is a reasonable addition to standard ultrasound. The following clinical situations are now considered the main indications for the use of the most common compression elastography (Fig. 2–7):

The presence of a solid palpable formation, requiring clarification of its nature;

The presence of a non-palpable formation in the gland to clarify its nature;

Differential diagnosis of a small cyst with dense contents and a small fibroadenoma;

The presence of an inflammatory infiltrate;

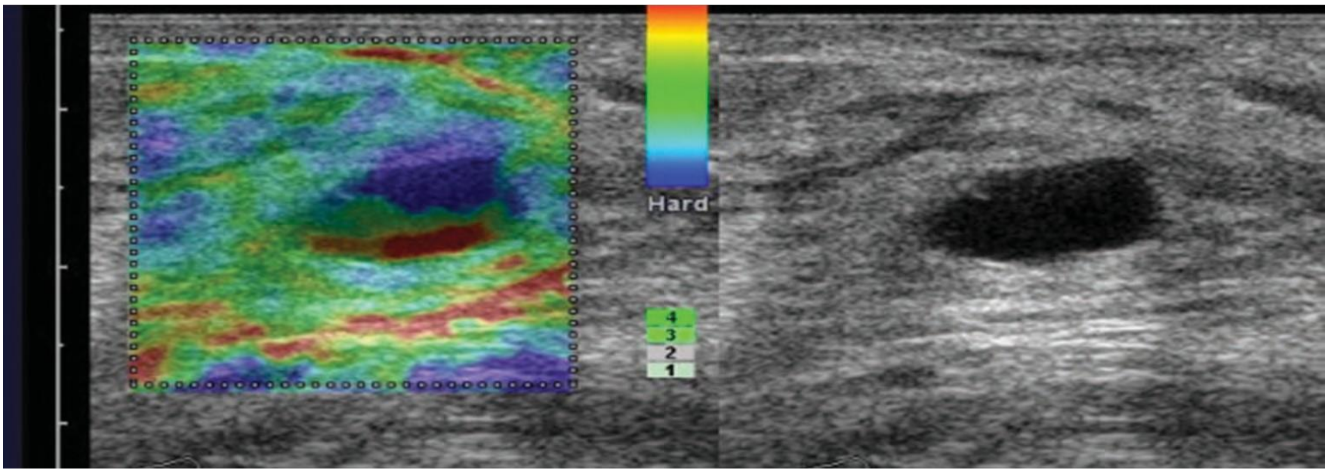


Figure.2. breast cyst

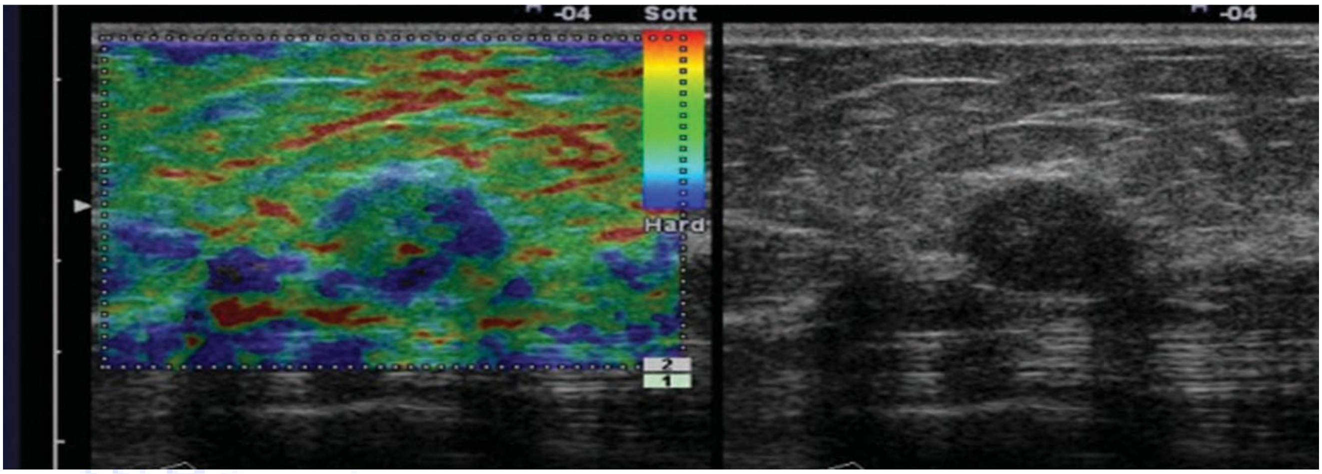


Figure.3. Fibroadenoma of the breast

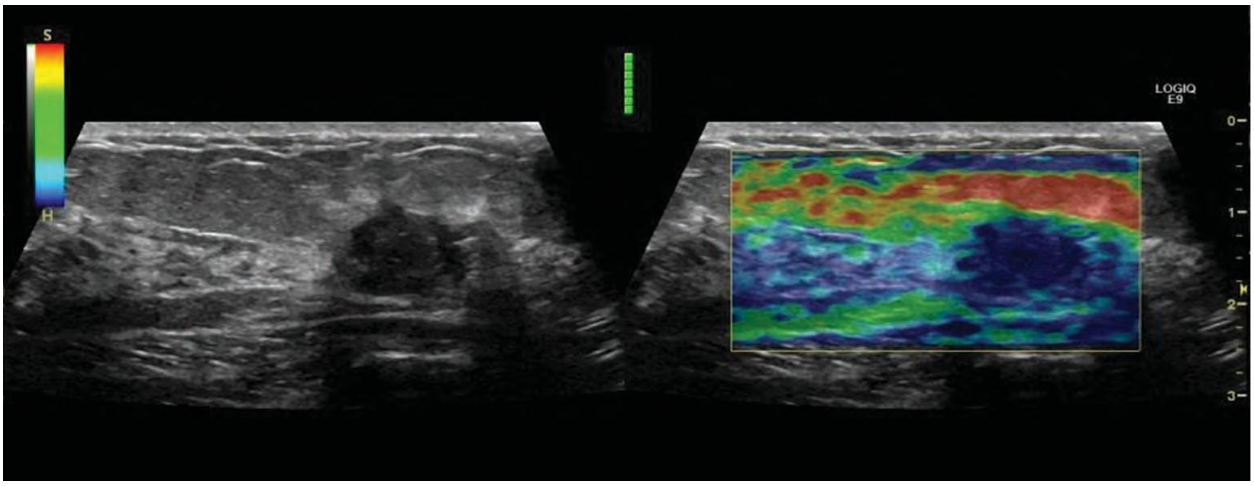


Figure.4. breast cancer

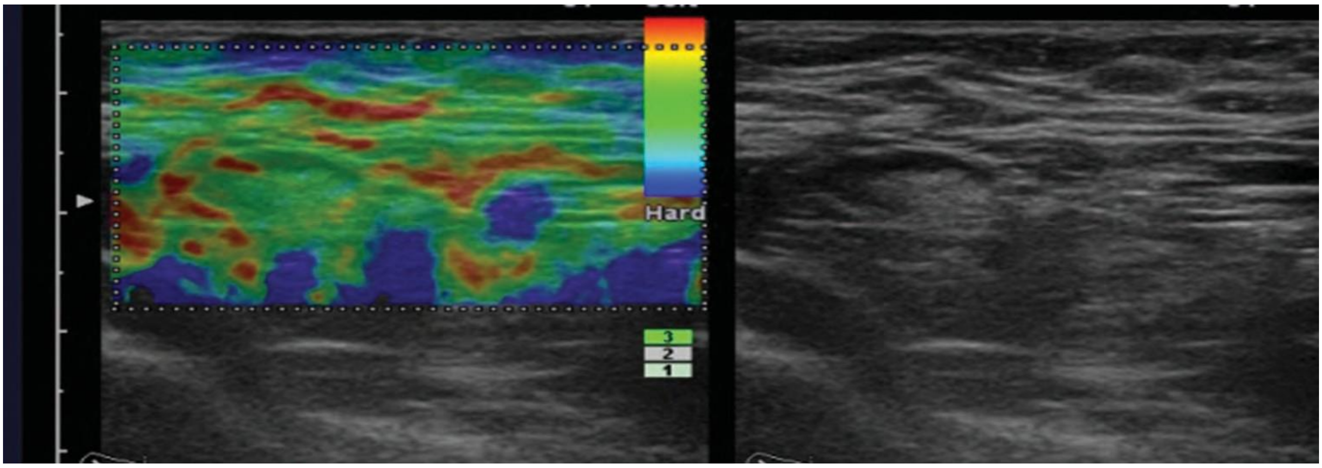


Figure.5. Unaltered lymph node assessment of the state of regional lymph nodes.

Mammographic digital tomosynthesis, first introduced in early 2011 as an approved technology for breast cancer diagnostics, is a promising area of modern diagnostic mammology.

According to device manufacturer Hologic, this system has been available outside the US since 2008.

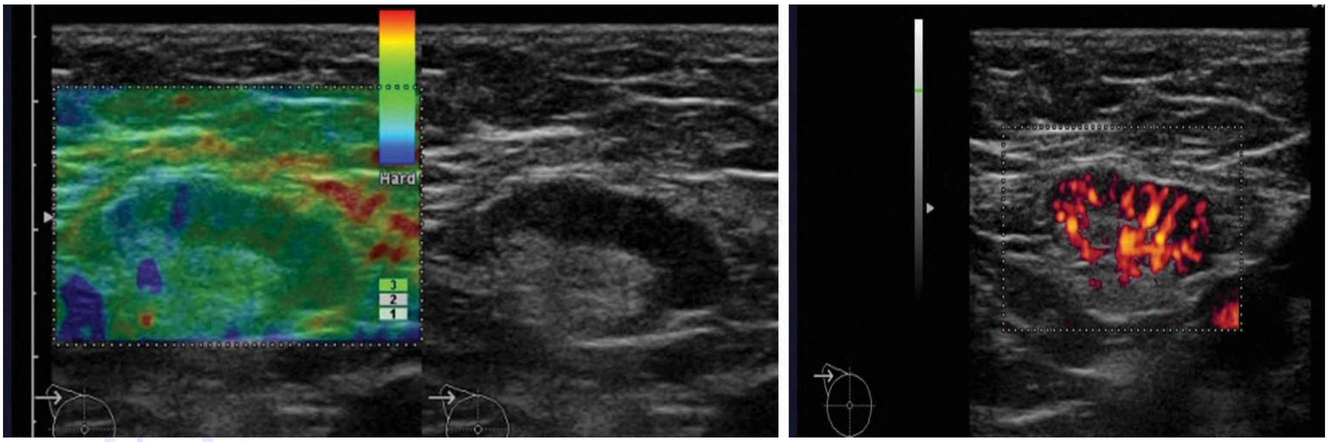


Figure.6. reactive lymph node

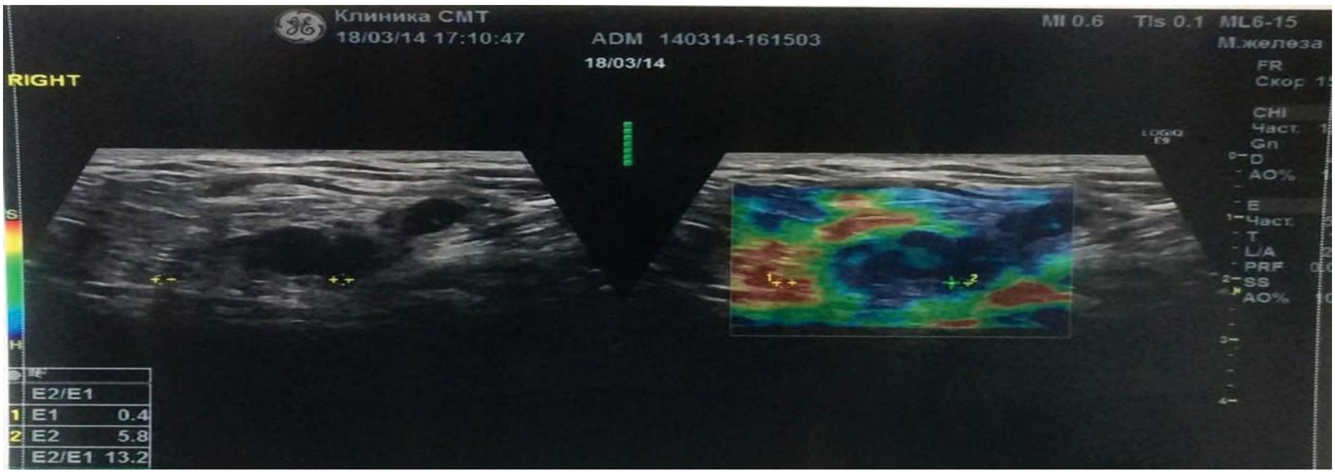


Figure.7. Metastatic lymph node

The tomosynthesis technique consists in summing up a series of mammograms in several projections. After that, the images in different projections are reconstructed, which makes it possible to obtain a

three-dimensional image of the tissue and significantly reduce the degree of projection overlap of the structures of the mammary gland.

Exposure: 15 projections at an angle of 15° (for all mammary glands). Reconstructions: sections of the mammary gland 1 mm thick (35 sections for a gland 3.5 cm thick, 60 sections for 6 cm, etc.) (Fig. 8). Short scan time in tomosynthesis mode (< 5 s). Possibility to acquire images in 2D, 3D, 2D + 3D modes.

In order to compare standard mammography and tomosynthesis, N.I. Rozhkova et al. 160 women were examined [30]. In 24 of them, fibro-fatty involution was detected, in 78 - diffuse mastopathy of varying severity, in 58 - fibrocystic mastopathy. On standard mammograms against the background of diffuse changes, nodules and calcifications were detected in 128 (80%) patients, in the tomosynthesis mode - in 135 (84%) patients. When identifying single formations with clear contours on mammograms, the evaluation of the reconstructed images in 4 cases revealed additional shadows of the formations and in 5 cases - formations in the absence of visibility due to a dense background. In 5 (3%) patients, tomosynthesis did not confirm the presence of pathological tissue remodeling. According to the authors, the mode of tomosynthesis allows to clarify the nature of the contours of the identified formations. In 13 women, mammograms revealed formations with fuzzy (7.8%) and radiant (2.3%) contours in places. When viewing layered images, the contours of these formations were clearly visualized throughout the entire volume, which made it possible to exclude the malignant nature of the identified changes.

According to D. Gasel (Yale Institute of Medicine), tomosynthesis can be used as an accessory to a conventional 2D mammograph, but not as a replacement. In a retrospective analysis of the results of a survey of 14,684 women who underwent mammography at Yale University from August 2011 to July 2012, the author noted an increase in the efficiency of diagnosing breast cancer by 11% among women who underwent examinations on both devices - 2D and 3D. At the same time, tomosynthesis is more informative when examining a dense mammary gland.

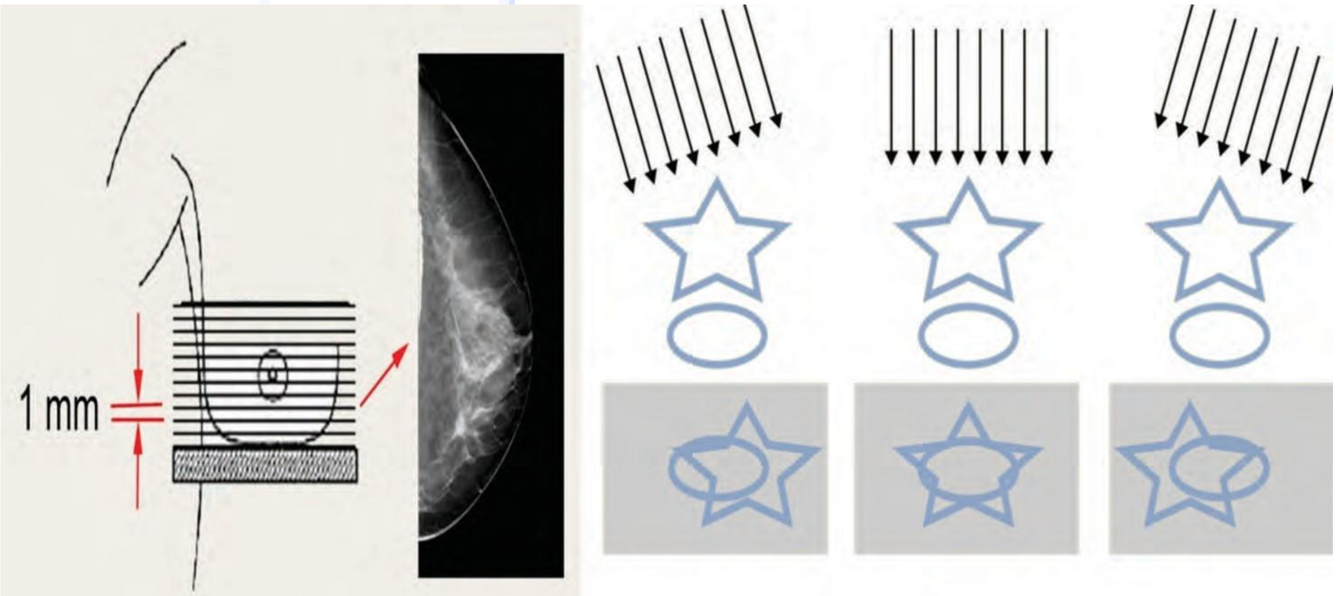


Figure.8. Scheme of work of tomosynthesis

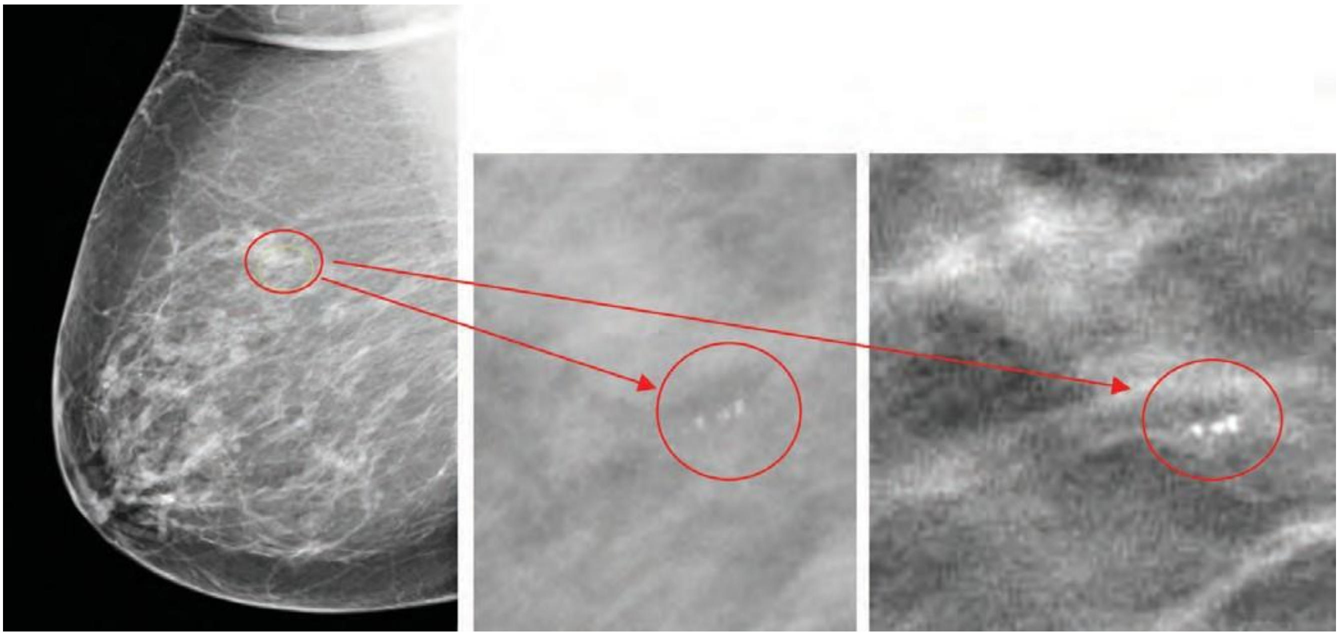


Figure.9. Microcalcifications. Digital photo. Tomosynthesis

In January 2013, the results of a survey of 12,600 patients were published in Oslo. The introduction of 3D imaging into the usual 2D format diagnostics showed an increase in diagnostic efficiency by 40% with a decrease in the number of false positive diagnoses by 15%. Similar data are given when evaluating the results of the STORM project (use of tomosynthesis or mammography).

According to E. Rafferty et al., when comparing the effectiveness of 2D + 3D versus 2D (1083 women were examined), the following was obtained: sensitivity increased from 66 to 76%, specificity from 81 to 89%, and the number of repeated calls decreased by 43% (Fig. 9, 10).

Currently, thanks to the developments of the Hologic company, a biopsy attachment is being introduced into practice, which will allow for a targeted study for histological verification of the diagnosis in 3D imaging reconstruction.

However, despite the first and very optimistic data, this technique is still far from the standard.

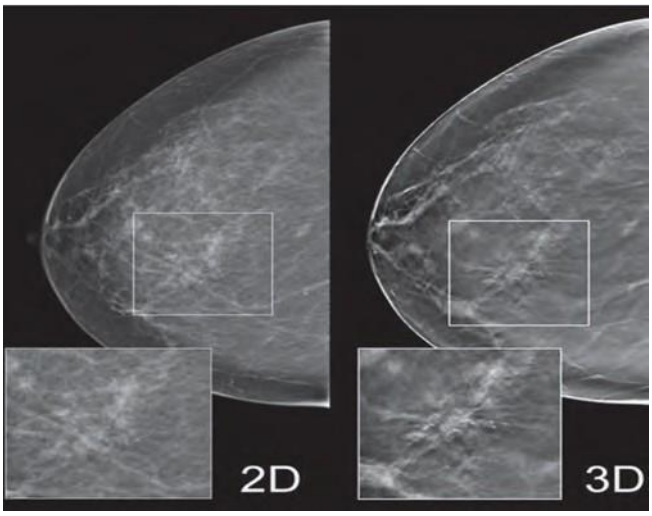


Figure.10. The 2D mammogram shows microcalcifications on the right. Reconstructed tomosynthesis section showing structural stretch (on biopsy: ductal intraepithelial carcinoma)

It is necessary to clearly understand in what age group this method may be optimal, what clinical situations will become the standard indication for its use, and, finally, whether tomosynthesis will require a combination with other methods of radiation diagnostics to obtain the maximum amount of information.

Comprehensive diagnosis of breast pathology, in addition to clinical data and imaging results, is based on information obtained from biopsies. At the present stage, the core biopsy is considered to be the optimal method of verification, in which the obtained material is subjected to immunohistochemical (IHC) examination. Such a tactic is the standard for breast cancer, since it determines the molecular portrait of the disease with a practical solution in the form of an individual algorithm, primarily systemic therapy. In oncological practice, the IHC study makes it possible to reveal the molecular structures of tumor cells associated with the degree of differentiation, the ability to invade and metastasize, sensitivity to chemotherapy, the course and prognosis of the disease in a particular patient. IHC analysis should be performed when there are insurmountable difficulties in establishing the histogenesis of the tumor, in immunophenotyping of malignant lymphomas.

However, the IHC study, which is widely used in clinical practice, has a number of disadvantages. The main ones include: loss, masking of the antigen, as well as long-term preparation of preparations. An alternative may be a method for determining the expression of molecular markers at the cellular level - an immunocytochemical (ICC) study. The material for the study is obtained with a conventional fine-needle puncture biopsy, which is simple to perform, less traumatic, but at the same time allows you to get a sufficient amount of cellular material. With small and non-palpable formations, this type of biopsy is carried out under navigation control (ultrasound or radiological navigation).

The ICC study does not require a lot of time, it is performed within 2–3 hours. Comparison of the results of the expression of molecular markers in the ICC and IHC methods was carried out by a number of researchers. A good correlation was obtained: the agreement between the results of ICC and IHC studies ranged from 61 to 92%.

At the same time, it was noted that membrane and cytoplasmic markers are more often positively stained in cytological than in histological preparations. This may be the result of a more gentle processing of cytopreparations, the absence of loss and masking of antigens during the passage and deparaffinization of the material using aggressive chemicals.

However, this method also has some disadvantages: poor quality of smears or a small number of cells in cytopreparations. The use of liquid systems allows to solve the arising problems.

The Cytology Sample Preparation Machine, Model ThinPrep 5000 Processor with ThinPrep Imaging System is a fully automated system for the preparation of cytology samples by liquid-based cytology. Allows multiple slides to be made from a single patient specimen, each with the ability to be homogeneous and to ensure reproducible results.

The use of a preservative liquid allows a number of additional studies, such as ICC study, detection of infectious agents and molecular diagnostics on the remaining material. The device holds up to 20 samples per batch with a delayed start option and is compatible with a computer imaging system.

The Imaging Station scans each cell and cell group on the slide, measuring the DNA content and identifying diagnostically significant cells or cell groups based on cellular characteristics. Processing of 1 glass slide takes 4.5–5.5 minutes.

The Cytology Sample Preparation Machine, Model ThinPrep 5000 Processor with ThinPrep Imaging System, has the following features:

Dual Review technology - each slide is analyzed by ThinPrep Imager and reviewed by a qualified cytologist, combining human expertise with cutting-edge technology to achieve more accurate clinical diagnosis;

technology for visualization of microscopic fields of diagnostic interest with automated movement of the microscope position;

processing of a batch of 250 slides with the ability to work without the presence of an operator;

storing patient slide data with a unique identification number. Automated marking of objects for subsequent revision.

Thus, the range of diagnostic possibilities is constantly expanding. Highly informative techniques included in everyday practice already allow clinicians to achieve optimal results in curing even more patients.

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